FISHERY RESEARCH

KOOTENAI RIVER FISHERIES INVESTIGATION: STOCK STATUS OF BURBOT

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Project Progress Report

2002 Annual Report

By

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ABSTRACT

The U.S. Army Corps of Engineers provided requested flow conditions to monitor burbot *Lota lota* movement during the winter of 2001–2002; this was made possible by low precipitation and snow pack. However, our captures of burbot were among the lowest since this investigation began in 1993. As a result, the flow test was ineffective. From October 1 through November 27, 2001, Kootenai River discharge at Libby Dam was stable at 170 m^3/s. We recorded 17 captures of burbot in Idaho and British Columbia, six of which were recaptures from this winter or previous years. Two additional burbot, which were too small to be retained in the web, escaped while we were raising our hoop nets; based on previous age analysis they may have been age-1. Captured burbot ranged from 509 to 841 mm total length and weighed from 600 to 1,753 g. Seven burbot were monitored with sonic telemetry, five of which were tagged the previous winter. During the prespawn period of 2001-2002, sonic-tagged burbot exhibited limited movement patterns despite the low flow conditions. The only apparent environmental difference noted was the warmer Kootenai River temperatures in November and December relative to previous years. The capture of burbot at Ambush Rock during the spawning period supports results of previous findings that low flows during November through January enhances burbot migration and spawning; one burbot provided circumstantial evidence of spawning, and we recorded movements of tagged fish during the low flows. Sampling for larval burbot was conducted on April 2, 2002 at rkm 152 and rkm 169.9 in the Kootenai River. The nets filtered a total water volume of 8,746.8 m^3. No larval burbot were captured. We collected nine blood samples for plasma steroid analysis from the Kootenai River adult population, 11 blood samples from the Columbia Lake population (the control), and 15 samples from burbot held at the Kootenai Tribe of Idaho Hatchery (held for experimental culture purposes). Our blood sample for plasma steroid analysis was too small to draw unbiased conclusions regarding reproductive physiology or reproductive dysfunction. We are unaware of any mortality of burbot from which blood was drawn from the Kootenai River or Columbia Lake; however, five mortalities (33%) from the hatchery occurred within 24 h.

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INTRODUCTION

In Idaho, burbot *Lota lota* are endemic only to the Kootenai River (Simpson and Wallace 1982). Burbot in the Kootenai River (Figure 1) once provided an important winter fishery to residents of northern Idaho. Some anglers reported catching up to 40 burbot per night during winter setline fishing (Paragamian 1994a). Prior to 1972, the annual harvest of burbot from the Kootenai River by sport and commercial fisherman in Idaho may have been in the tens of thousands of kilograms; three commercial anglers alone harvested an estimated 2,150 kg in 1958 (Idaho Department of Fish and Game [IDFG] Regional Archives, unpublished). Burbot caught during the winter fishery are thought to have been part of a spawning migration from the lower river and Kootenay Lake in British Columbia (BC), Canada. However, after construction and operation of Libby Dam by the U.S. Army Corps of Engineers (USACE) in 1972, the fishery rapidly declined and was closed in 1992. Concomitant to the collapse in Idaho was the collapse of the burbot fishery in Kootenay Lake, BC (Paragamian et al. 2000). Operation of Libby Dam for hydroelectric power and flood control has created major changes in the river's seasonal flow, particularly during the winter when burbot spawn (Figure 2). The temperature regime and nutrient supply of the Kootenai River are also thought to be important factors for burbot spawning and recruitment; they, too, have changed further since construction of Libby Dam (Partridge 1983; Richards 1996; Snyder and Minshall 1996).

The Kootenai River Fisheries Investigation was initiated in 1993 by IDFG to address burbot abundance, distribution, size structure, reproductive success, and movement, and to identify factors limiting burbot. Only one burbot was captured between rkm 246 (Bonners Ferry) and the Montana border (rkm 275) from 1993 through 1994 (Paragamian 1994b). There has been little evidence of burbot reproduction in the Idaho reach (rkm 170-275). Only one larval burbot was captured from 1993 to 2001; however, numerous size-classes of burbot were in the catch, indicating successful reproduction. Previous studies of Kozfkay and Paragamian (2002) had failed to document a spawning run of burbot from the lower river or Kootenay Lake, but cooperative sampling in the BC reach of the river with the British Columbia Ministry of Water, Land, and Air Protection (BCMWLAP) documented spawning burbot in the Goat River, BC.

Studies completed in the winter of 1997-1998 indicated flow management at Libby Dam likely affected burbot spawning migration (Paragamian 2000). Movement of burbot with sonic transmitters was significantly higher ($p < 0.01$) during low flow test conditions, which were designed to replicate pre-dam Kootenai River flow. Movement upstream was also significantly higher during low flow tests than the control ($p = 0.009$), despite the fact there were low flows during the controls. Winter flows are now three to four times greater than they were historically, when conditions were relatively stable. Daily differences in flow can now reach up to 652 m^3/s. Fluctuating flows from Libby Dam, caused by hydropower production and floodwater evacuation, appear to have continuously disrupted upstream migrations of burbot (Paragamian et al. in progress). The specific effect of this disruption to burbot spawning migration and spawning is unknown, but it may have reduced spawning fitness and stamina or affected timing of burbot spawning (DiStefano et al.1997). One or all of these possible factors could have been sufficient to reduce spawning success and recruitment.

To help clarify which mechanisms are reducing spawning success and recruitment, we studied the reproductive physiology of burbot in the Kootenai River during 2001 and 2002. Normally, seasonal changes in environmental cues, such as temperature or photoperiod, initiate behavioral and physiological responses in fish before and during the spawning season (Moyle 1988). Changes in these cues are relayed from the nares, eyes, or other structures to the

hypothalamus and pituitary that produce reproductive steroids necessary for final gonad development and successful spawning (Redding and Patiño 1993). In Missouri, DiStefano et al. (1997) compared the reproductive physiology of walleye *Stizostedion vitreum* from the tailwater of Harry S. Truman Dam that were subjected to an altered thermal and flow regime to walleyes from an unregulated segment of the North Fork of the White River. Their data indicated that walleyes in the tailwater of Truman Dam were reproductively dysfunctional and serum profiles of reproductive steroids were irregular when compared to walleye from the unregulated river segment and to another population (the control population). Using a similar study design, we sought to compare reproductive steroids of burbot from the Kootenai River to those of a healthy, naturally reproducing burbot population from Columbia Lake, BC, Canada. Burbot from Columbia Lake are thought to be similar to burbot from the Kootenai River in terms of spawning behavior and timing (Arndt and Hutchinson 2000) and, therefore, acted as the control for our study. The Columbia Basin Fish and Wildlife Compensation Program, through the cooperation of the BCMWLAP, operated a weir on the primary spawning tributary during the winter of 2001 that facilitated blood collection from postspawn burbot. Our results for the winter of 2000-2001, a low flow year, suggested there was no evidence of stress in burbot (Kozfkay and Paragamian 2002).

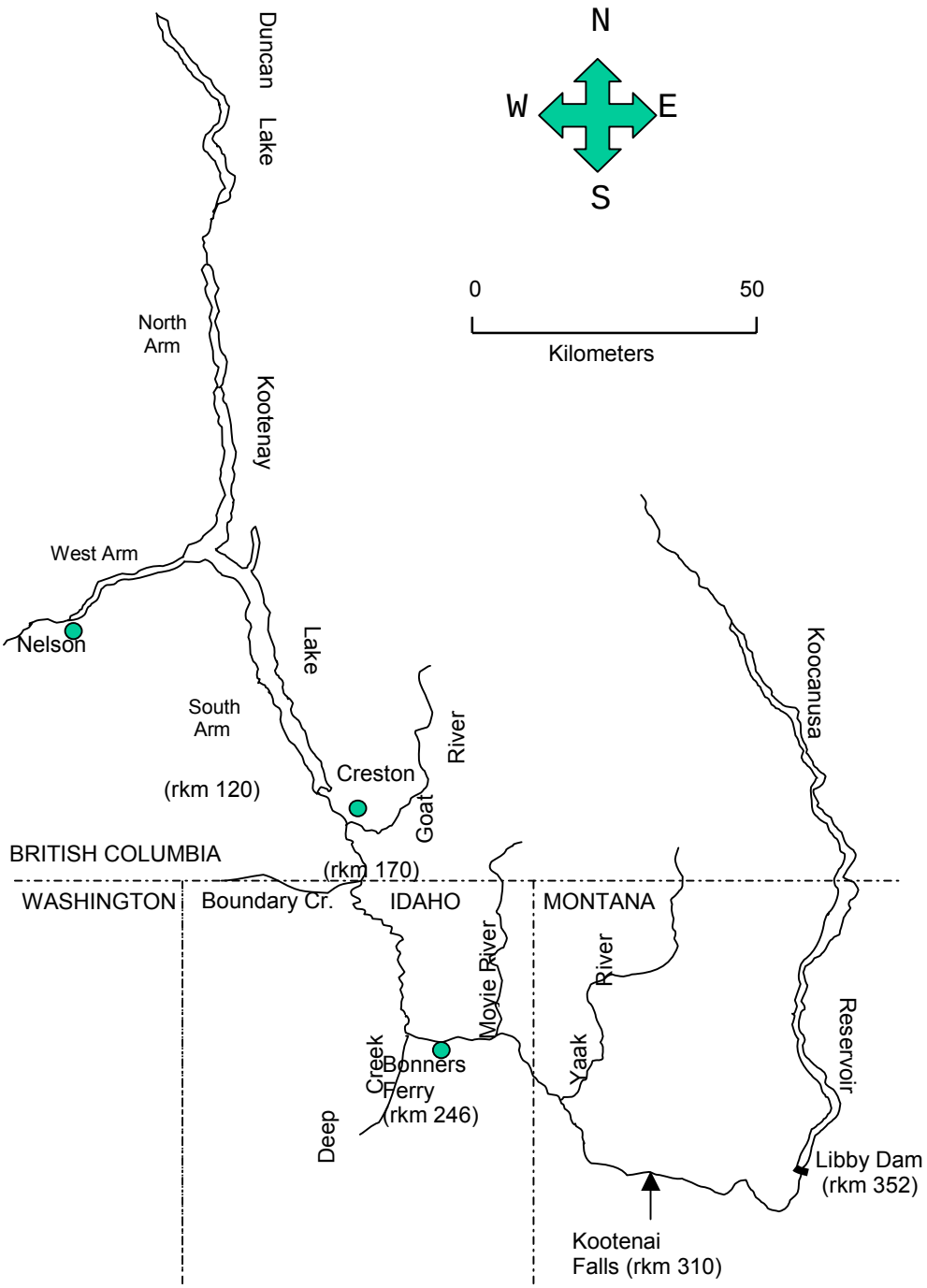

Figure 1. Location of the Kootenai River, Kootenay Lake, Lake Koocanusa, and major tributaries. The river distances from the northernmost reach of Kootenay Lake are in river kilometers (rkm) and are indicated at important access points.

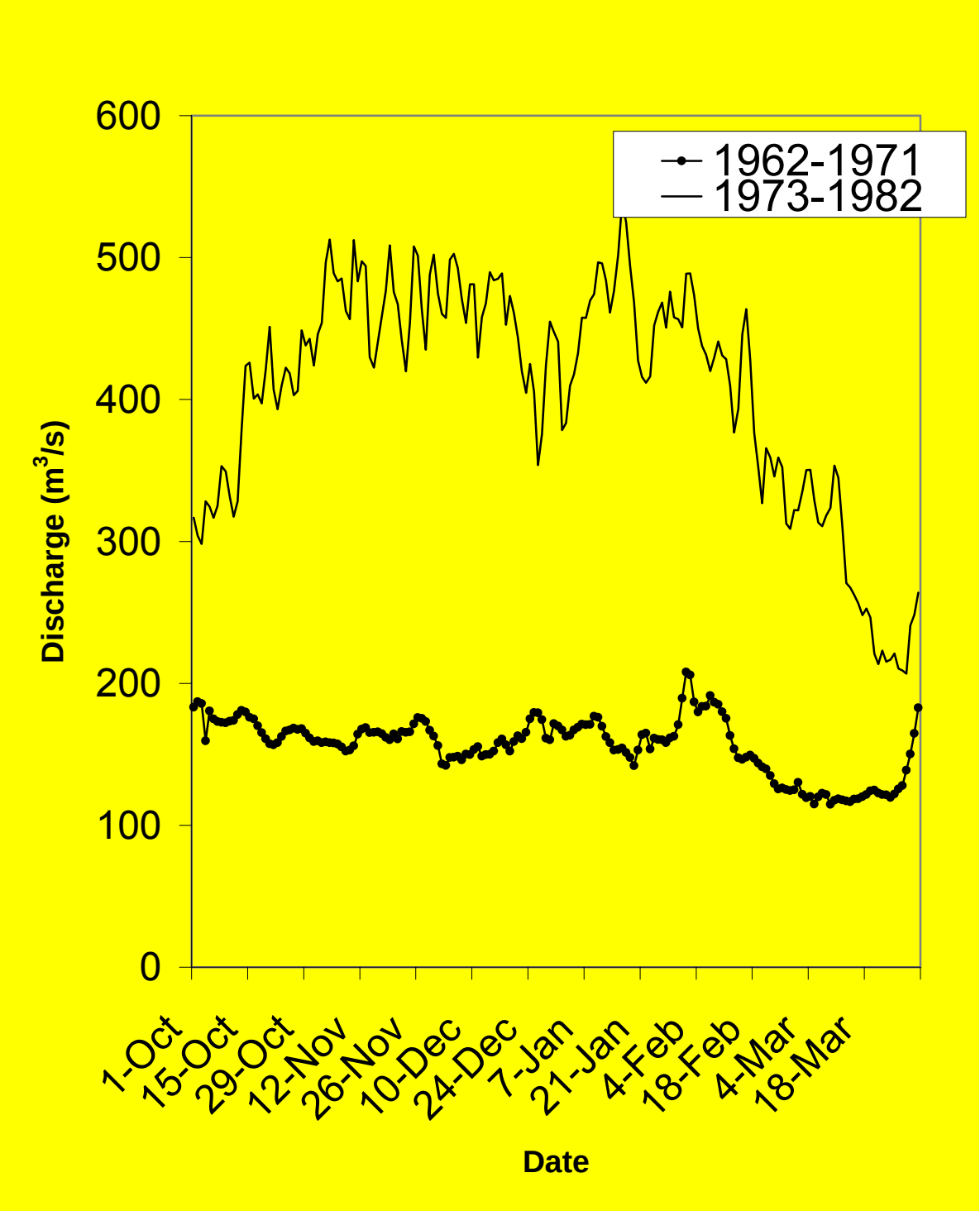

Figure 2. Mean monthly discharge (m^3/s) in the Kootenai River at Bonners Ferry, Idaho, from 1962 through 1971 (pre-Libby Dam) and from 1973 through 1982 (post-Libby Dam).

GOAL

The management goal of this study is to facilitate restoration of the burbot population in the Idaho reach of the Kootenai River and to restore angler fishing success to historic levels.

OBJECTIVES

1. Identify factors limiting burbot within the Idaho portion of the Kootenai River drainage and recommend management alternatives to restore the fishery to self-sustainable levels.

2. Define factors limiting burbot migration and reproductive success to improve survival and recruitment of young burbot.

3. Test the null hypothesis (H_o) that winter operation of Libby Dam does not affect burbot migration distance or travel rate.

4. Determine if there is a stress relationship between flow in the Kootenai River and burbot reproductive physiology by comparing plasma steroids of burbot from the Kootenai River to a control population in Columbia Lake, BC.

STUDY AREA

The Kootenai River (spelled Kootenay for Canadian waters) is one of the largest tributaries to the Columbia River. Originating in Kootenay National Park, BC, the river flows south into Montana where Libby Dam impounds water into Canada and forms Lake Koocanusa (Figure 1). From Libby Dam, the river flows west and then northwest into Idaho, then north into BC and Kootenay Lake. The Kootenai River at Porthill, Idaho drains about 35,490 km^2. The reach in Idaho is 106 km long. Kootenay Lake drains out the West Arm, and eventually the river joins the Columbia River near Castlegar, BC.

The Kootenai River presents three different channel and habitat types as it passes through Idaho. As the river enters Idaho, steep canyon walls and a gradient of about 0.6 m/km typify the corridor. The river begins a short braided reach about one km below the Moyie River, then at Bonners Ferry the river transitions to a lower gradient of approximately 0.02 m/km and meanders through a broad flood plain. Tributary streams of the Kootenai River are typically high gradient as they pass through mountain canyons yet revert to lower gradients when they reach the valley floor where they have been diked.

METHODS

Discharge and Temperature

Daily discharge and temperature values for the Kootenai River at Libby, Montana were obtained from the USACE and the U.S. Geological Survey (USGS) water resources web site. A temperature logger (Stowaway XI) was used to monitor daily water temperatures for Smith and

Boundary creeks in Idaho, as well as Summit Creek, Corn Creek, and the Goat River in BC, from October 2001 through March 2002. At each location, mean temperature was calculated from five evenly spaced daily measurements. A temperature logger was deployed less than 200 meters upstream of each tributary confluence with the Kootenai River. In Summit and Boundary creeks, an additional thermograph was placed approximately 500 meters farther upstream to assess the infiltration of warmer water from the Kootenai River. Data from these loggers will be used to assess whether infiltration of Kootenai River water into these creek mouths was substantial, in which case the cold water inputs that burbot may use as migration cues would be obscured (Paragamian 2000). Although no burbot spawning has been documented recently, Summit and Boundary creeks are historical burbot spawning areas.

Sampling Adult Burbot

We sampled for adult burbot from October 17, 2001 through April 11, 2002 using up to 12 baited hoop nets. Hoop nets had a maximum diameter of 0.61 m (see Paragamian 1995 for description of nets and method of deployment). Nets were deployed in deep (usually the thalweg) areas of the Kootenai River between Ambush Rock (rkm 244) near Bonners Ferry, Idaho and Nick's Island (rkm 144) near Creston, BC. We also sampled three tributaries including Smith Creek near Porthill, Idaho (rkm 177), Boundary Creek, which enters the Kootenai River at Porthill, Idaho (rkm 170), and the Goat River near Creston, BC (rkm 152).

Nets were usually lifted on Monday, Wednesday, and Friday of each week. We decompressed all burbot by lowering the net to 50% of its original depth, waiting 24 h, and then raising it halfway again before final lifting to the surface. This procedure usually took several days, depending on initial depth. Fish captured in hoop nets were identified by species, enumerated, measured for total length (TL), and weighed to the nearest gram (g). Sex of some burbot was determined by a gentle massage near the abdomen and examination of the vent for gametes. All burbot were implanted with a passive integrated transponder (PIT) tag in the left opercular muscle. Relative weight (W_r; Fisher et al. 1996) was calculated for each burbot captured. Catch per unit effort (CPUE) was measured in catch per 24 h with each net-day as a 24 h period.

Burbot Telemetry

Sonic transmitters were used to track adult burbot movement throughout the year. Sonic transmitters had a 420 d life expectancy, were cylindrical in shape, measured 18 mm by 65 mm, and weighed 8 g. Sonic transmitters were surgically implanted (see Paragamian 1995 for description of surgical procedures). When possible, the sex of each burbot was determined during surgery. Sonic telemetry was conducted from a boat primarily on days alternate to net lifting and occasionally on the same day as net lifts. When burbot were located by telemetry, the location was recorded to the nearest 0.1 rkm.

Blood Collection and Analysis

Blood was collected from anesthetized burbot using a 25 mm 20-gauge needle and a 10 ml heparinized vacuum tube (Strange 1983). Each fish was placed in a cradle with its ventral side up, and a sterile needle 5 mm long was inserted posterior of the anus along the midline. After insertion, the needle was slowly pushed until it reached the vertebral column, and then the

vacuum tube was punctured with the opposite end of the needle. If blood did not flow into the tube immediately, the needle was either moved laterally or additional downward pressure was applied until 1-4 ml of blood was collected. Blood was stored in a cooler on ice or snow. As soon as possible, usually within 4 to 6 hours of collection, blood was centrifuged for five minutes at 5,000 X gravity. Serum was removed with a pipette, placed in a sterile plastic container, and frozen at –20°C.

All samples were extracted with anhydrous ether to purify the steroids from any binding proteins in the plasma and analyzed in duplicate using radioimmunology assay (RIA) by personnel at the Oregon Cooperative Fishery Research Unit at Oregon State University (Beth Siddens, Oregon State University, personal communication). Levels of testosterone (T), estradiol-17ß (E_2), and 11-ketotestosterone (11-KT) were measured and are expressed as nanograms/ml (ng/ml).

Larval Sampling

Larval burbot sampling was conducted using paired ½ m nets (mouth area = 0.7854 m^2) on April 2, 2002 in the Kootenai River with a boat 8 m in length. One net was towed at the surface, while the other sampled approximately 1.5 m below the surface. Gurley 2030 R current meters were mounted in the mouth of each net, and tows were made in a downstream direction. The boat motor (150 hp) was operated at 1,000 rpm. Downstream tows were made at mid channel near Ambush Rock (rkm 247), while tows downstream to the mouth of the Kootenai River (rkm 124.7) were conducted near the shoreline. Effort was calculated using total towing time and rotation counts per second from the flow meters x mouth area of net (0.7854 m^2) to calculate the total volume of water filtered through each net.

RESULTS

Discharge and Temperature

Kootenai River Discharge

During the winter of 2001–2002, the USACE provided requested flow test conditions to monitor burbot movement. Discharge of the Kootenai River at Libby Dam was stable at 170 m^3/s from October 1 through November 27, 2001 (Figure 3). Discharge was increased to 266 m^3/s by November 29, 2001 and was increased to about 268 m^3/s to provide a flow test from December 1 through December 23. Discharge was increased thereafter to 410 m^3/s and was stable at 410 m^3/s for four weeks. From February 5-14, 2002, discharge increased rapidly to 679 m^3/s, then dropped gradually to 226 m^3/s. Discharge remained at 226 m^3/s until March 6, 2002 and then gradually decreased to 113 m^3/s by March 13, 2002. Discharge stayed at 113 m^3/s through March 31, 2002.

Kootenai River Temperature

Mean daily water temperature for the Kootenai River at Bonners Ferry ranged from 2.2 to 6.1°C from December 2001 through mid February 2002. The coldest temperatures did not

occur until late February and March 2002 when on three occasions temperatures decreased to 0.3 to -0.1°C (Figure 4).

Tributary Temperatures

Temperatures of four tributaries of the Kootenai River in Idaho and BC, Canada were monitored from about October 28, 2001 through April 11, 2002. The continuous recorder at Corn Creek failed. Mean water temperature of Smith Creek was 1.30°C (Figure 5). The maximum temperature of 9.21°C occurred on October 31, 2001, whereas the minimum temperature of -1.66°C occurred on February 15, 2002. At the upstream site in Boundary Creek, mean water temperature was 2.54°C with a maximum of 5.0°C on November 3, 2001 and a minimum of –0.05°C on many days in December and January (Figure 6). In lower Boundary Creek, mean water temperature at the mouth was 1.55°C and ranged from a maximum of 5.12°C on November 3, 2001 to a minimum of -4.25°C on March 7, 2002 (Figure 7).

Mean water temperature of the Goat River through winter was 2.03°C (Figure 8). The maximum temperature of 6.86°C occurred on November 4, 2001, whereas the minimum temperature of –4.11°C occurred on December 27, 2001. At the mouth of Summit Creek (lower Summit Creek), mean daily water temperature was 0.99°C and reached a maximum of 22.4°C October 28, 2001 but achieved a minimum of –4.29°C on March 7, 2002 (Figure 9). Mean water temperature at the upstream site of Summit Creek was 1.62°C with a maximum of 7.24°C on October 31, 2001 and a minimum of -0.01°C during most of December and on several days in January and February (Figure 10). The mouths of the tributaries were warmer than the upper sites. The mean difference from late October 2001 to early April 2002 in mean temperature between the mouth and the upstream location in Boundary and Summit creeks were 0.73°C and 1.15°C, respectively.

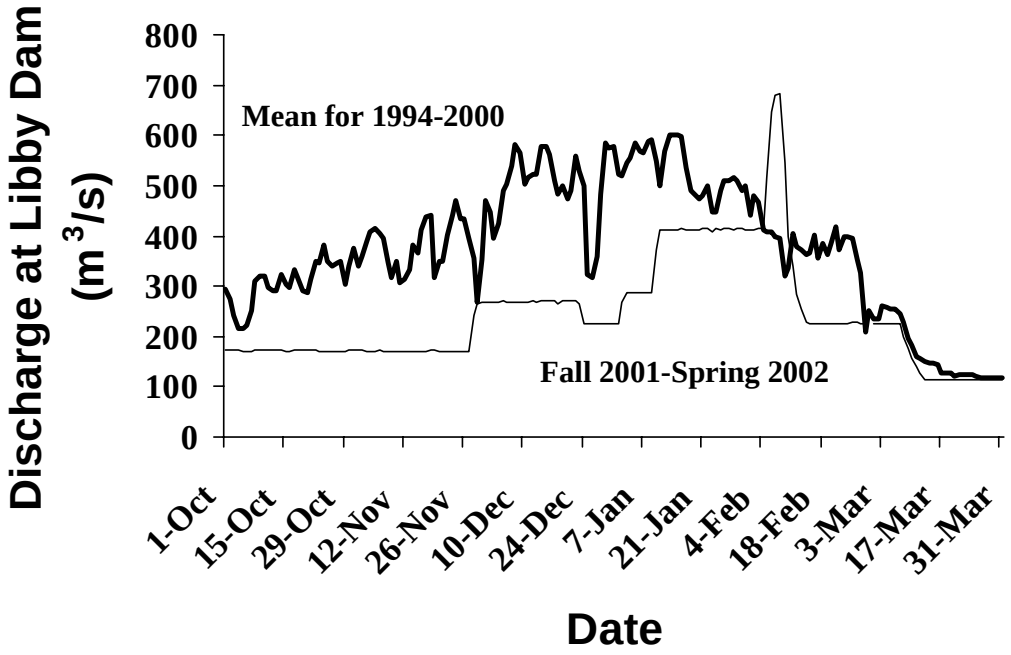

Figure 3. Kootenai River discharge (m^3/s) at Libby Dam from October 1, 2001 through March 31, 2002 and the mean for 1994-2000.

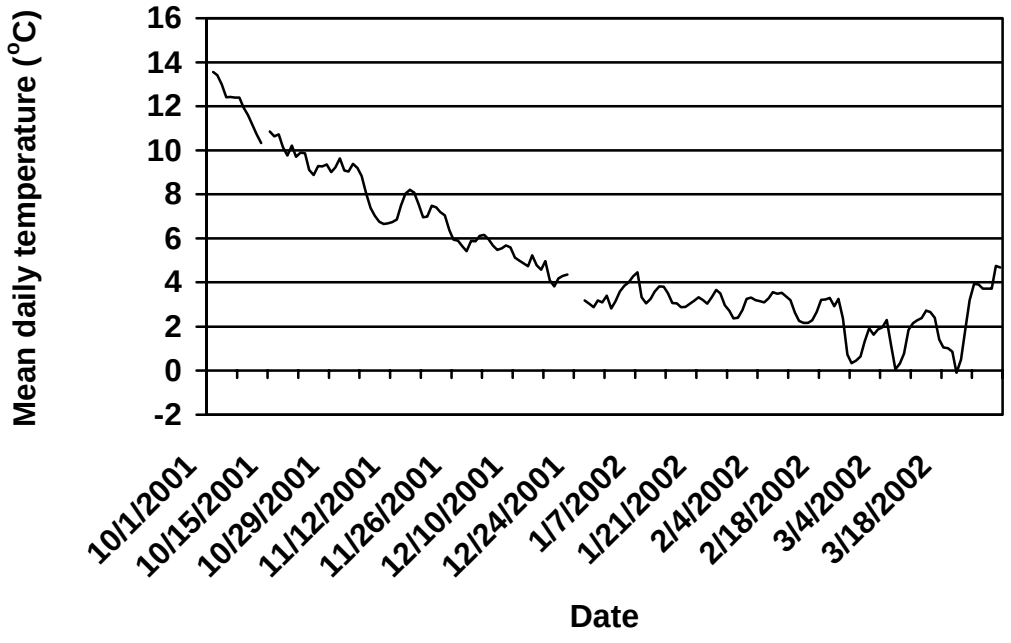

Figure 4. Mean daily temperature (°C) of the Kootenai River at Bonners Ferry from October 1, 2001 through March 31, 2002.

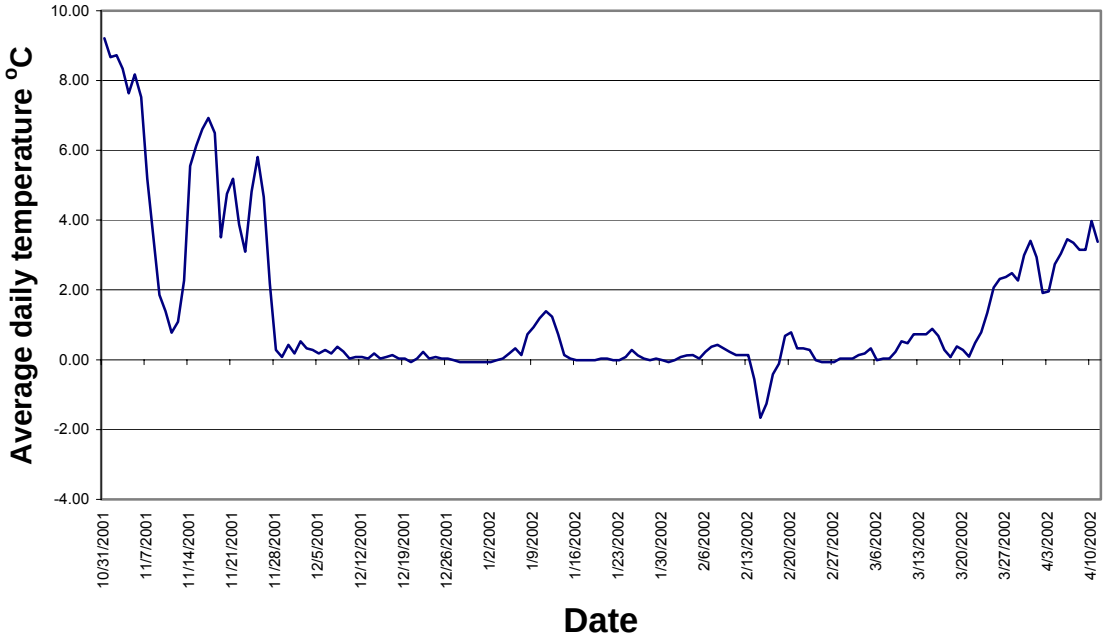

Figure 5. Mean daily temperature (°C) of Smith Creek from October 31, 2001 through April 10, 2002.

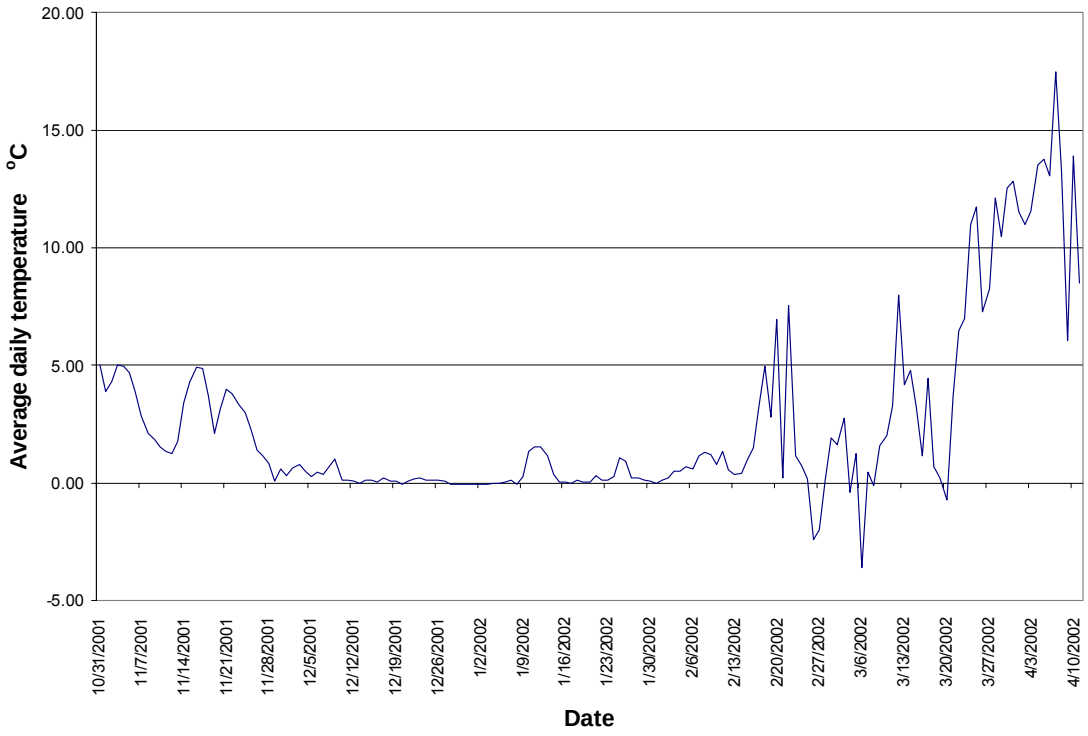

Figure 6. Mean daily temperature (°C) of upper Boundary Creek from October 31, 2001 through April 10, 2002.

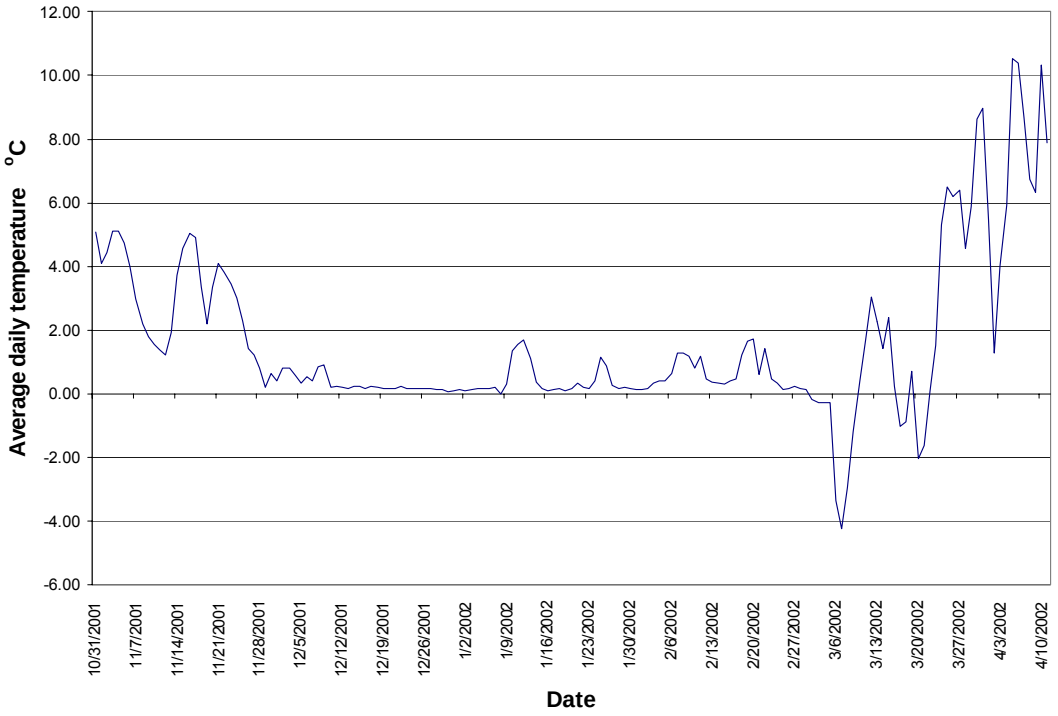

Figure 7. Mean daily temperature (°C) of lower Boundary Creek from October 31, 2001 through April 10, 2002.

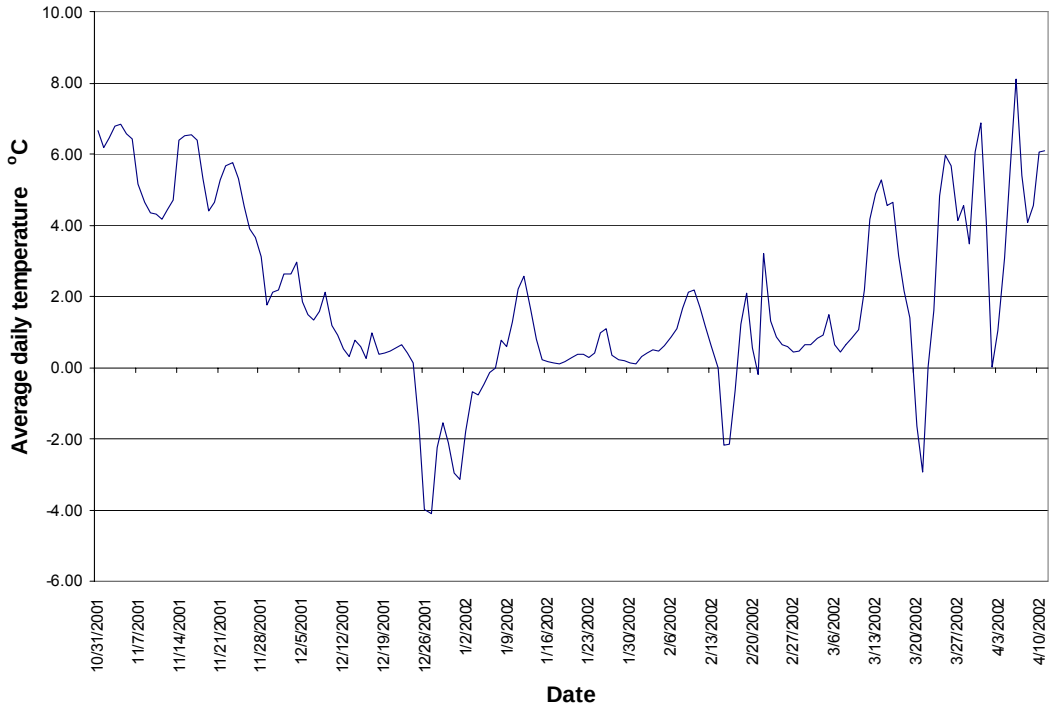

Figure 8. Mean daily temperature (°C) of the Goat River from October 31, 2001 through April 10, 2002.

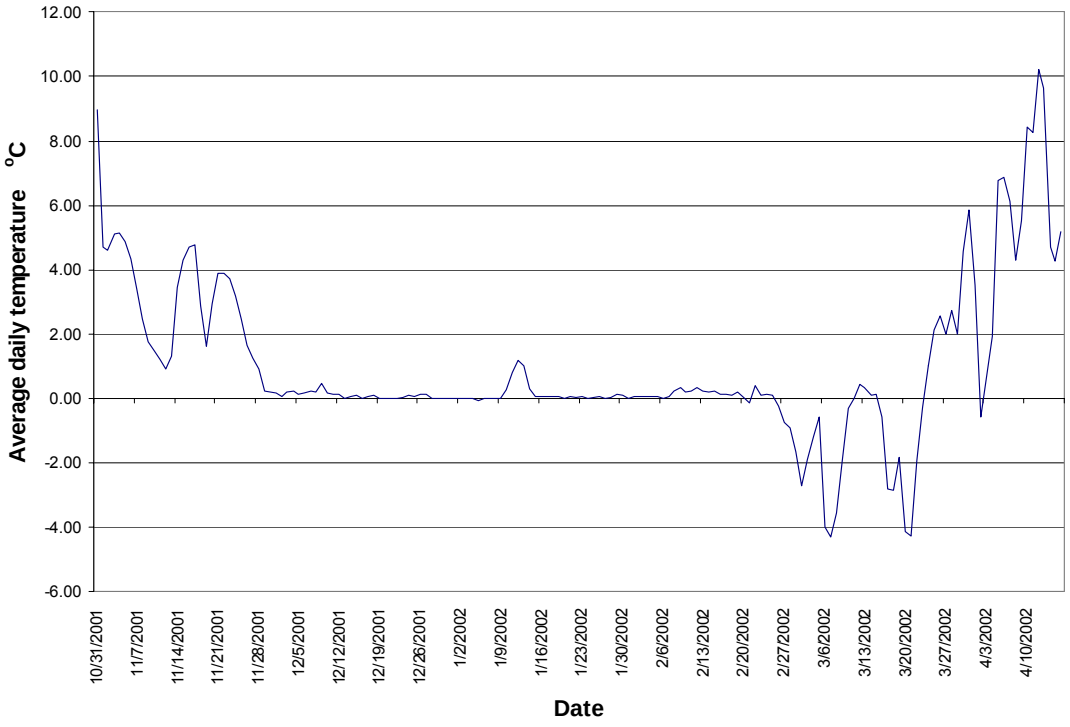

Figure 9. Mean daily temperature (°C) of lower Summit Creek from October 31, 2001 through April 10, 2002.

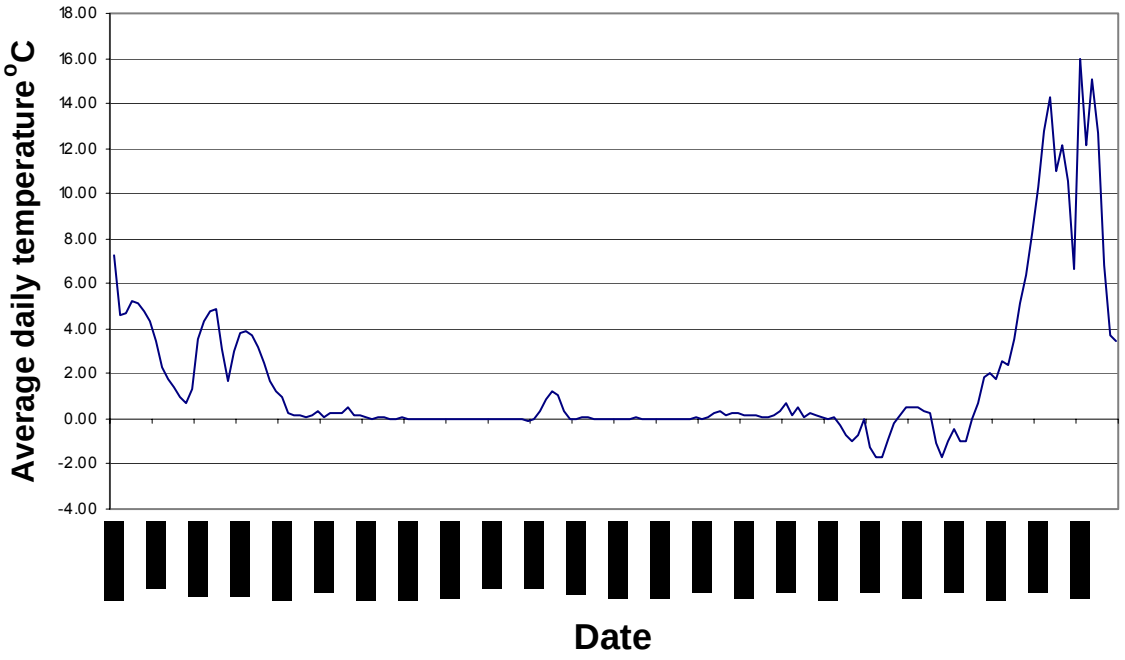

Figure 10. Mean daily temperature (°C) of upper Summit Creek from October 31, 2001 through April 10, 2002.

Sampling Adult Burbot

Total Catch

We fished baited hoop nets from October 17, 2001 to April 10, 2002 for a total of 35,552 h or 1,481 net d. A total of 114 fish were caught, including ten different species of fish and 78 crayfish (Table 1). Catch per unit of effort was 0.0768 fish/net d for all species of fish (crayfish excluded) and 0.011 fish/net d for burbot or one burbot captured every 87 net d (Table 1).

Hoop Net Catch of Burbot

Overall, we captured 17 burbot in Idaho and BC, 11 of which were in Idaho and six in BC (Table 1, Figure 11). All of the burbot captures in Idaho occurred at Ambush Rock. Six of the burbot captures at Ambush Rock occurred on February 19, 2002. Six burbot were recaptures from previous years, one of which was also caught twice during this field season as well as once during a previous year. Two burbot that were included in the total catch escaped through the hoop net web after decompression before they could be brought into our boat. As a result, these fish were not marked.

We obtained length and weight measurements from 14 burbot (fish repeatedly captured over a short time period were excluded). Burbot ranged from 509 mm to 841 mm TL (mean = 640 mm, SD = 84) (Figure 11) and weighed from 600 g to 4,700 g (mean = 1,753 g, SD = 1,070). Relative weight (W_r) ranged from 63 to 116 and averaged 95 (SE = 1.94).

We captured one burbot during what we believe was the prespawn period and then recaptured it after spawning. Burbot 212, a female, was captured on February 4, 2002 and weighed 3,250 g. It weighed 3,100 g when it was recaptured on February 19, 2002.

Table 1. Hoop net catch by number, weight (kg), and catch per unit effort (CPUE) for the Kootenai River and its tributaries in Idaho and BC, Canada, October 2001 through April 2002.

Species	Number	Total Weight (kg)	CPUE[a]
Northern pike minnow *Ptychocheilus oregonensis*	53	27.23	0.036
Burbot	17	27.65	0.011
Crayfish *Pacifastacus spp.*	78	3.40	0.053
Longnose sucker *Catostomus catostomus* and *C. macrocheilus*	11	1.93	0.007
Peamouth chub *Mylocheilus caurinus*	7	0.85	0.005
White sturgeon *Acipenser transmontanus*	12	3.22	0.008
Bull trout *Salvelinus confluentus*	4	3.61	0.003
Brook trout *S. fontinalis*	3	1.93	0.002
Rainbow trout *Oncorhynchus mykiss*	5	1.52	0.003
Yellow perch *Perca flavescens*	2	0.15	0.001
Total	114[b]	68.08[b]	0.0768[b]

[a] A unit of effort is a single net set for 24 hours.
[b] Crayfish excluded from total.

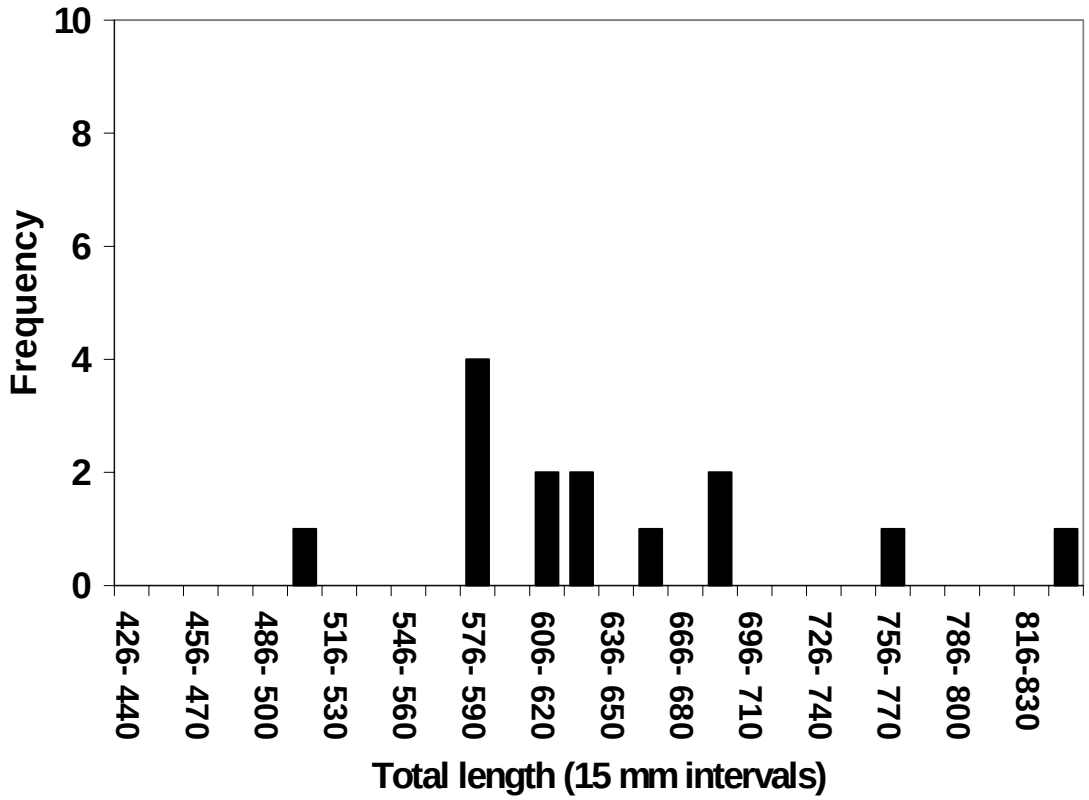

Figure 11. Length frequency distribution of burbot caught by baited hoop nets, excluding recaptures, in the Kootenai River and its tributaries in Idaho and BC, Canada, from October 2001 through April 2002.

Burbot Telemetry

Seven burbot were monitored with sonic telemetry during the winter of 2001-2002 (Table 2 and Appendices 1-7). We spent 90 hours tracking burbot from rkm 122 to 245 from October 2001 through March 2002. We contacted tagged burbot 105 times during this period. Additional telemetry effort was made through August during white sturgeon studies.

Two burbot were surgically implanted with sonic transmitters during October and November 2001, including one male and one of unknown sex (Fish #255 and 258, Table 2). Both of these fish were captured in British Columbia at rkm 150.8. Five burbot were previously tagged during the winter of 2000-2001 (Table 2). Two previously tagged burbot tracked during this field season were captured in BC. These two burbot (Fish #232 and 234, Appendices 4 and 5) were originally captured in the Goat River in early February 2001. Burbot 232 moved upstream to rkm 155 by March and remained in this area until mid January 2002. This fish then moved downstream to the mouth of the Goat River, stayed in that area through most of February, and moved back upstream to rkm 155 by March 2002. In the two weeks following its capture, burbot 234 moved 12 km downstream to rkm 140. Shortly thereafter, this fish moved upstream to rkm 146 where it remained until mid January 2002. At that time, burbot 234 moved

upstream to the mouth of the Goat River. This fish could not be found on February 22, 2002 and was assumed to be in the Goat River. By early March, burbot 234 had moved back downstream to rkm 146.

Three other burbot from the 2000-2001 field season were originally captured in Idaho. Burbot 211 was relatively sedentary, spending much of the time in the vicinity of rkm 244.6 and 236.5. Burbot 218 was captured at Ambush Rock in January 2001 (Table 2 and Appendix 2). This fish gradually moved downstream and arrived at Kootenay Lake (rkm 122) by early September 2001. Burbot 218 by mid November had moved back upstream to rkm 206 and traveled back and forth between rkm 193 and rkm 208 until the transmitter battery died in early February 2002. Burbot 230 was captured at the mouth of Boundary Creek (rkm 170) in January 2001 (Appendix 3). This fish remained within three kilometers of Boundary Creek until June 2002. Burbot 230 later migrated upstream to rkm 185 by November and stayed within two kilometers of this location for the remainder of the winter. However, during May it progressively moved upstream to rkm 239.1 where it was located near the bank of the river (approximately 5 m). It gradually moved downstream, and by mid August it was at rkm 173.

One of the newly tagged burbot (Fish #255) migrated 19 km upstream to rkm 169 during the month of November 2001 (Appendix 6). This fish then dropped back downstream to the mouth of the Goat River in December. Burbot 255 exhibited a second upstream migration to rkm 157 in January 2002 but returned to the mouth of the Goat River by late February. The other newly tagged burbot (Fish #258) moved slightly upstream to rkm 152 shortly after capture (Appendix 7). This burbot remained at this location until February 2002, when it was found approximately 1.2 km upstream in the Goat River.

Table 2. Summary of telemetry data and physical characteristics of seven burbot in the Kootenai River, Idaho and BC, Canada, January 2001 through November 2001.

Sonic Code	Fish Number	PIT Tag Number	Release Site (rkm)	Release Date	Depth (m)	Total Length (mm)	Weight (g)	Sex	Last Date Located
2239	211	7F7D434A22	244.6	01/29/01	20.4	650	1725	M	2/20/02
325	218	7F7D041608	244.6	01/29/01	15.8	568	1400	F	5/6/02
2228	230	7F7D0F066A	170.0	01/30/01	19.2	578	1200	M	08/14/02
2249	232	7F7D424630	152.7	02/02/01	11.9	500	975	—	9/18/02
2632	234	7F7D374B5A	152.7	02/05/01	2.4	561	1100	F	3/8/02
7254	255	7F7D37D17	150.8	10/29/01	74.0	615	1650	—	9/18/02
7256	258	7F7D3E7665	150.8	11/14/01	55.0	613	1100	M	2/22/02

Blood Collection and Analysis

Kootenai River Burbot

From January 26 through March 9, 2002, we collected nine blood samples from burbot in the Kootenai River (Appendix 8). Blood was sampled from four male burbot and five burbot of unknown sex. Blood was drawn for plasma steroid analysis from burbot that were in prespawn through postspawning condition. In the Kootenai River, males had a mean level of T of

3.73 ng/ml (SE = 2.71; n = 4); mean levels of 11-KT were 4.98 ng/ml (SE = 3.10), and mean E_2 level was 0.37 (SE = 0.11). Our samples of T, KT, and E_2 from blood taken from male burbot in the Kootenai River were inadequate for analysis of a temporal trend.

Kootenai Tribe of Idaho Hatchery Burbot

We collected 15 blood samples on April 18, 2002 from burbot held at the Kootenai Tribe of Idaho (KTOI) Hatchery well after the spawning season (Appendix 9). Hatchery males had a mean level of T of 3.23 ng/ml (SE = 2.41; n = 7); mean levels of 11-KT were 1.59 ng/ml (SE = 0.28), and mean E_2 level was 0.58 (SE = 0.35). In the hatchery, females had a mean level of T of 0.28 ng/ml (SE = 0.24; n = 8); mean levels of 11-KT were 0.96 ng/ml (SE = 0.31), and mean E_2 level was 0.48 (SE = 0.13). Although burbot in the Kootenai Tribe of Idaho Hatchery were held for experimental culture, 10 of 15 burbot did not reach full maturity for spawning. Five of 15 burbot died within a day of drawing blood.

Columbia Lake Burbot

In 2002, no weir was constructed in the unnamed tributary to Columbia Lake, BC; however, burbot were captured in the tributary using dip nets. On February 13, 2002, we collected 11 blood samples from burbot in the tributary, including five fish positively identified as males, two as females, and four fish of unknown sex (Appendix 10). These fish were believed to be at postspawn or spawning condition. In Columbia Lake, males had a mean level of T of 0.76 ng/ml (SE = 0.63; n = 5); mean levels of 11-KT were 1.83 ng/ml (SE = 0.47), and mean E_2 level was 0.23 (SE = 0.04). In Columbia Lake, females had a mean level of T of 0.38 ng/ml (SE = 0.38; n = 2); mean levels of 11-KT were 1.17 ng/ml (SE = 0.06), and mean E_2 level was 0.29 (SE =<0.01).

Larval Sampling

Sampling for larval burbot was conducted April 2, 2002 at rkm 152 and rkm 169.9 in the Kootenai River. Four paired ½ meter net tows were made, averaging approximately 20 minutes each. Total towing time was 1 hour, 11 minutes, and 10 seconds. The nets filtered a total water volume of 8,746.8 m^3. No larval burbot were captured.

DISCUSSION

Accomplishment of our objectives during the winter of 2001-2002 was limited in scope because of the low number of burbot captured prior to flow and movement studies. Only 17 burbot were caught, few of which were caught before December 2001. The low sample size limited the progress of our plasma steroid analysis, monitoring of burbot by telemetry was incomplete, and mark and recapture for population estimates and demographic analysis was inadequate. We believe our low catch success during the winter of 2001-2002 was primarily due to the diminishing numbers of burbot in the Kootenai River.

Flows from Libby Dam ranging from 180 to 400 m^3/s from October 2001 through January 2002 resulted in a second year of exceptionally low flows and suspected burbot spawning. This observation is based on the capture of six burbot at Ambush Rock during the spawning season

in mid-February and the recapture of a female that was thought to have spawned because of a decrease in weight. In addition, two small burbot that escaped through the web of our hoop net were most likely evidence of successful spawning in 2001. Partridge (1983) aged burbot in the Kootenai River using otoliths and found that age-1 and -2 fish were about 200 and 340 mm TL, respectively. Based on studies of Bernard et al. (1991) burbot can be caught in hoop nets at about 350 mm TL but are not fully recruited until 450 mm TL. Thus, we believe the two small burbot were most likely from the 2001 year class. Drought conditions during the winter of 2000-2001, when flows were usually below 200 m^3/s, also created favorable conditions for burbot spawning (Kozfkay and Paragamian 2002). Continuation of low flows during winter will benefit burbot by providing suitable flow conditions for migration and spawning (Paragamian 2000; Kozfkay and Paragamian 2002).

Burbot Population Status

Our total capture of 17 burbot in 2001-2002 was the lowest catch of the nine years of this investigation. Our best estimate of total population size was 540 burbot, calculated in 1998-1999 (Paragamian and Whitman 2000) when our mark and recapture effort was more evenly distributed than other years of study. Since the beginning of this investigation, March of 1993 through November of 2002, 327 burbot have been captured, of which 61 were recaptures, for a total of 266 different fish. Some burbot have been recaptured up to five times.

Consistent capture of burbot occurred in only a few distinct areas: Ambush Rock, Idaho and in and near the Goat River, BC. This happened despite our attempt to distribute effort uniformly. In fact, over half of the burbot captures during this study segment occurred at Ambush Rock during late January and the first two weeks of February 2002. These locations may also represent significant spawning locations. During the winter of 2000-2001, we captured over 20 fish at Ambush Rock; both male and female burbot were identified as gravid, flowing, or spent. These fish represented the largest known spawning congregation of burbot in Idaho within the last decade. In addition, our highest catches of burbot in the Goat River occurred during this same time when gravid and spent fish were identified (Paragamian 1994a, 1994b; Paragamian 1995, 2000; Paragamian and Whitman 1996, 1997,1998; Kozfkay and Paragamian 2002).

The limited movement of burbot in November and December 2001 and early January 2002 may have been influenced by the warmer winter water temperatures of 2001-2002. Mean daily water temperature in the Kootenai River ranged from 2.2 to 6.1°C from December 2001 through mid February 2002. The coldest temperatures did not occur until late February and March 2002 when on three occasions temperatures dipped down to 0.3 to –0.1°C. Water temperature at the same time period during the winter of 2000-2001 was about 2°C cooler, ranging from 0-4°C, and burbot were thought to be more active earlier in the season. In 1999-2000, flows and temperatures were higher. Mean daily water temperature in the Kootenai River ranged from a maximum of 12.4°C for October 9, 1999 to a minimum of 2.4°C for February 22, 2000. There was no evidence of spawning that winter. The importance of post-Libby Dam water temperature and burbot spawning is an unresolved question regarding their decline. Our understanding could be enhanced with a well-designed laboratory study.

Plasma Steroid Studies

We continued to evaluate plasma steroid levels during the winter of 2001-2002, because in previous studies we captured unspawned females (reabsorbing eggs) and unspent males during the postspawn season. These findings suggested maturing burbot were either subjected to a stressful environment or spawning synchrony had been disrupted leading to a failure to spawn (Paragamian and Whitman 1996 and 1997). We believe high fluctuating flows from Libby Dam have continuously disrupted burbot migrations (Paragamian 2000) and may be responsible for the failure of spawning. The use of plasma steroid analysis appeared to be an efficient method to address this question (DiStefano et al. 1997). Evidence of stress in fish can be documented in the level of plasma steroids remaining high before and after the spawning period. Analysis during the winter of 2000-2001, when we found evidence of burbot spawning, suggested a normal trend in the temporal reduction in each of the three plasma steroids (Kozfkay and Paragamian 2002). These results further substantiate that under the low flow conditions prevalent in 2000-2001, male and female burbot were able to mature, migrate, and spawn.

Plasma steroid studies during this past season were far less helpful than the previous year. For example, because of an inadequate sample size, we were unable to statistically compare prespawn to postspawn values of T, 11-KT, and E_2 from male and female burbot. As a result, we will discontinue sampling blood for plasma steroid analysis for several reasons. First, the burbot population is so low our samples during the winter of 2001-2002 were insufficient to detect the temporal changes in plasma steroids; most fish are captured late in the field season. Second, it is difficult to determine the sex of burbot without intrusive means. Last, it is not known if the mortality experienced with the hatchery fish was due to technique or individual operating skill. Because of these concerns, we believe it is advisable to do stress studies under laboratory conditions with a stock of burbot that is not in decline.

Recommended Flows for Burbot Migration and Spawning

Because burbot in the Kootenai River may be at risk of demographic extinction (Paragamian 2000), a Conservation Strategy (Anonymous 2002) was prepared to outline measures necessary to rehabilitate burbot. The Conservation Strategy indicated that operational flow changes at Libby Dam must be implemented during winter to provide suitable conditions for burbot migration. However, the upper limit of flow releases for adequate burbot spawning migration and flood control were unknown for inclusion in a Conservation Agreement, the next phase. Experimental flows were proposed with the USACE and the Bonneville Power Administration (BPA) from 1998-2002, initially at 170 m^3/s from Libby Dam (similar to pre-dam winter flows) for burbot spawning migration (Paragamian and Whitman, 1999, 2000; and this study). The intention was to test the null hypothesis that winter operation of the dam does not inhibit burbot migration distance or travel rate. However, studies were largely ineffective because of hydropower and flood management priorities of the BPA and the USACE in 1998 through 2000. Studies from 2001 through 2002 (Kozfkay and Paragamian 2002; and this study) were hampered because population numbers of burbot were so low adequate sample size for movement studies were not possible. Since test conditions were unachievable, an alternative evaluation was necessary (Paragamian et al., in progress). The objective was to examine existing telemetry records of burbot collected from 1994 through 2000 (Paragamian 1994b, 1995; Paragamian and Whitman 1996, 1997, 1998, 1999, 2000) to further determine how flow factors affect burbot travel distance and travel rate.

Records of 68 burbot monitored with sonic and radio transmitters from 1994 through October 2000 were examined (Paragamian et al., in progress). Burbot travel distance and rate, by distance and time, were established by examining those records of a travel distance of 5 km or more in 10 days or less, herein referred to as "stepwise movement." This criterion was established because past experience trapping and telemetry of burbot suggested most burbot resided in the Kootenai River in BC from about rkm 150 downstream including Kootenay Lake (Paragamian 2000). In our studies, many burbot were caught from rkm 143-152. Burbot traveling from the lower Kootenai River in BC from approximately rkm 145 or lower had a minimum travel distance of about 45 km in order to reach historic spawning tributaries in Idaho (e.g., Smith or Boundary creeks). Thus, burbot would have a necessary travel rate of at least 5 km within 10 d within an estimated travel time of about 90 days (mid November through mid February). Paragamian et al. (in progress) had 1,835 telemetry contacts; 1,494 contacts occurred during the October through February period (81%) of 1994 through 2000. From this total 26 burbot (13 males, seven females, and six of undetermined sex) made 44 upstream migrations of 5 km or more in 10 d or less from October 1994 through September 2000 (Appendix 11). Distances ranged from 5 km in 6 d (0.8 km/d) to 65.9 km in 9 d (7.3 km/d) (Appendix 11). Travel rates ranged from 0.5 km/d to 11.1 km/d. Stepwise movements of burbot occurred during flows from Libby Dam that ranged from 112 m^3/s to 658 m^3/s.

Paragamian et al. (in progress) examined the seasonal distribution of stepwise movements and found 30 (68%) of the 44 movements occurred when flows were ≤300 m^3/s from Libby Dam and averaged 176 m^3/s. Of the total number of observations, 26 (59%) occurred from October through February while 14 (32%) were during the postspawn period. Stepwise movements of burbot were examined to determine if there were statistical differences in movement when the number of days flows from Libby Dam were ≤300 m^3/s (N = 15 and 186 days, low flows) in comparison to the number of days flows were ≥301 m^3/s (N = 11 and 538, high flows). The Fisher exact test indicated burbot moved more frequently during lower flows ($p = 0.001$). There was no difference in the migration of burbot between sexes and flow ($p = >0.01$). Because of these studies, it was recommended flow for burbot prespawning migration should range from 113- 300 m^3/s and average 176 m^3/s for a minimum of 90 d (mid November to mid February).

RECOMMENDATIONS

1 We recommend a burbot prespawning migration and spawning flow from Libby Dam ranging from 113-300 m^3/s and average 176 m^3/s for a minimum of 90 d, beginning November 15, 2003 through February 15, 2004. Burbot spawning migration (arrival time) and evidence of spawning (spent burbot, eggs, and larvae) should be monitored at Ambush Rock to test the null hypothesis that burbot migration is not different than previous years of high flows (1996, 1997, 1998, and 1999).

2 Under laboratory conditions, monitor physiological condition and reproductive fitness of burbot by testing the effect of high velocities (>25 cm/s) and elevated winter temperatures on blood chemistry by measuring the level of testosterone, 11 ketotestosterone, and 17β estradiol, and compare these to a control.

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APPENDICES

Appendix 1. Location, date, water temperature, and depth of burbot 211 as determined by sonic telemetry and depth sounder.

Date	Location (rkm)	Depth (m)	Water Temperature (°C)
1/26/01	244.6	20.42	
2/2/01	244.5		
2/6/01	244.6	20.12	
2/6/01	244.3		
2/8/01	244.3		
2/9/01	244.5	16.76	
2/9/01	244.4		
2/12/01	244.5		
2/13/01	244.5	20.12	
2/16/01	244.2		
2/21/01	243.0		
2/23/01	243.0		
2/2/7/01	243.0		
3/2/01	243.0		
3/5/01	243.0		
3/9/01	243.0		
3/12/01	243.0		
3/22/01	244.5		
3/28/01	244.4		
4/30/01	244.4		
5/3/01	238.5		
5/4/01	238.5		
5/7/01	237.3		
5/8/01	237.6		
5/9/01	238.2		
5/10/01	239.0		
5/11/01	239.0		
5/15/01	236.3		
5/16/01	233.1		
5/17/01	230.6		
5/18/01	229.6		
5/21/01	231.2		
5/23/01	229.6		
5/24/01	236.5		
5/25/01	244.3		
5/26/01	237.5		
5/27/01	229.5		
5/28/01	233.5		
5/29/01	229.9		
5/30/01	236.3		
6/4/01	234.2		
6/7/01	236.1		
6/11/01	227.0		
6/18/01	231.3		
6/24/01	245.4		
7/19/01	237.3		

Appendix 1, continued.

Date	Location (rkm)	Depth (m)	Water Temperature (°C)
11/2/01	236.5		9.5
11/9/01	236.4		
11/21/01	236.5		
12/3/02	236.5	5.2	
12/6/01	236.5	5.2	6.0
12/10/01	236.5	5.2	6.0
12/12/01	236.5	8.5	6.0
12/19/01	236.6	4.8	5.0
12/21/01	236.6		5.0
12/28/01	236.4	4.0	4.0
1/2/02	236.6	4.3	4.0
1/4/02	236.6		
1/7/02	236.6	4.3	4.5
1/9/02	236.6	7.0	5.0
1/11/02	236.6	4.6	5.5
1/14/02	236.6	5.2	3.0
1/22/02	236.6	6.1	4.0
1/24/02	236.6	4.0	4.0
1/28/02	236.6	6.1	4.0
2/20/02	236.6	4.0	4.0

Appendix 2 Location, date, water temperature, and depth of burbot 218 as determined by sonic telemetry and depth sounder.

Date	Location (rkm)	Depth (m)	Water Temperature (°C)
1/29/01	244.6	15.85	3.0
2/2/01	240.3		3.0
2/6/01	244.5	20.12	3.0
2/6/01	243.2		
2/21/01	207.0		3.5
2/23/01	207.0		3.5
2/26/01	208.2	27.43	
4/27/01	193.4	27.4	9.0
5/30/01	190.3		9.5
6/4/01	191.0		8.0
6/18/01	181.5		11.0
9/5/01	122.0		
9/24/01	119.5		
11/15/01	206.9	10.7	8.0
11/20/01	206.3	10.7	7.5
12/4/01	208.2	19.8	6.0
12/5/01	206.3	10.7	6.0
12/11/01	208.8	7.9	6.0
12/13/01	207.8		5.0
12/21/01	200.5		
1/3/02	193.2	30.2	4.0
1/8/02	193.3	22.6	6.0
1/10/02	192.7		4.5
1/15/02	207.2	21.3	4.0
1/16/02	207.2	20.4	4.0
1/30/02	193.2	32.0	3.0
1/31/02	193.3	23.8	3.5
2/4/02	193.2		4.0
5/6/02	219.0		7.5

Appendix 3. Location, date, water temperature, and depth of burbot 230 as determined by sonic telemetry and depth sounder.

Date	Location (rkm)	Depth (m)	Water Temperature (°C)
1/29/01	170.0	19.20	3.0
2/2/01	170.0		3.0
2/5/01	170.1		4.0
2/6/01	170.1		4.5
2/8/01	170.1		3.5
2/12/01	170.1		3.0
2/13/01	170.2		2.5
2/13/01	170.1		3.5
2/22/01	170.2		4.0
3/1/01	170.2		
3/8/01	170.2		
5/3/01	172.1		
5/30/01	172.1		9.0
6/18/01	173.2		11.0
11/15/01	185.0	27.4	8.0
11/20/01	183.5	28.0	7.5
11/27/01	185.5	22.3	5.5
12/4/01	185.4	16.8	6.0
12/5/01	185.8	9.75	6.0
12/11/01	185.7	25.0	6.0
12/13/01	185.4		5.0
12/17/01	185.3	24.1	5.0
1/3/02	185.6	22.9	4.0
1/8/02	185.5	22.6	6.0
1/10/02	185.0	16.8	4.5
1/15/02	183.6	14.6	4.0
1/16/02	183.6	17.7	4.0
1/18/02	185.5	22.3	4.0
1/23/02	185.5	16.5	4.5
1/29/02	185.5	22.9	4.0
1/30/02	185.5	19.8	3.0
1/31/02	185.5	22.9	3.5
2/4/02	185.5		4.0
2/6/02	185.5		4.5
2/11/02	185.5		4.5
2/13/02	185.5		4.5
2/15/02	185.5	21.6	3.0
2/19/02	185.5	21.0	4.0
2/27/02	185.7	26.5	4.0
3/4/02	185.6	20.1	3.0
3/11/02	185.6	25.3	3.0
5/6/02	212.0		7.5
5/28/02	237.5		9.0
5/30/02	239.1		8.0
6/3/02	238.2		9.5
6/7/02	228.5		9.0

Appendix 3, continued.

Date	Location (rkm)	Depth (m)	Water Temperature (°C)
6/10/02	229.2		8.5
6/11/02	228.5		9.5
6/17/02	236.2		11.0
6/21/02	227.5		12.0
6/22/02	228.7		12.0
6/26/02	228.5		12.0
6/28/02	231.6		12.5
7/2/2/02	226.0		11.5
8/14/02	173.0		16.5

Appendix 4. Location, date, water temperature, and depth of burbot 232 as determined by sonic telemetry and depth sounder.

Date	Location (rkm)	Depth (m)	Water Temperature (°C)
2/2/01	152.7[a]	11.89	3.0
2/2/01	153.1		3.0
2/5/01	153.7		4.0
2/6/01	153.3		4.5
2/8/01	153.3		3.5
2/12/01	153.2		3.0
2/13/01	153.2		2.5
2/15/01	153.3		3.5
2/20/01	153.2		1.0
2/22/01	152.7[a]		4.0
3/1/01	152.7[a]		
3/8/01	155.8		
3/13/01	155.1		
3/21/01	154.2		4.0
4/27/01	155.5		9.0
5/3/01	155.2	7.6	7.5
5/30/01	156.3		9.0
9/6/01	156.0		
10/29/01	155.0	18.9	8.5
11/14/01	155.7		8.0
11/19/01	155.4	17.4	8.0
11/26/01	155.5		10.5
11/28/01	155.9	14.6	6.0
12/4/01	155.2		
12/11/01	155.6		
12/18/01	155.7		
12/20/01	155.1	10.1	4.5
1/2/02	155.2		
1/8/02	155.2		
1/17/02	152.3		
1/25/02	153.4		
2/5/02	152.7[a]	14.6	4.0
2/22/02	152.7	10.1	4.0
3/8/02	155.6	10.4	1.5
3/15/02	154.9	6.1	
9/18/02	144.5	23.8	16

[a] In Goat River.

Appendix 5. Location, date, water temperature, and depth of burbot 234 as determined by sonic telemetry and depth sounder.

Date	Location (rkm)	Depth (m)	Water Temperature (°C)
2/5/01	152.7[a]	2.44	3.0
2/5/01	152.0		4.0
2/6/01	152.2		4.5
2/8/01	150.6		3.5
2/12/01	152.3		3.0
2/22/01	140.0		4.0
3/8/01	146.5		
3/13/01	146.5		
3/21/01	146.8		4.0
5/3/01	146.6	9.8	7.5
6/5/01	147.0		10.0
9/18/01	147.0		16.0
10/19/01	147.0	12.2	9.0
10/22/01	147.0		
11/7/01	147.0	10.1	
11/16/01	146.4	11.3	8.0
11/21/01	146.6	14.3	7.5
12/13/01	147.0		
12/18/01	146.5	12.2	5.0
1/4/02	146.8		
1/17/02	152.0		
1/25/02	150.8		
2/5/02	152.6	14.6	4.0
3/8/02	146.7	9.8	1.5

[a] In Goat River.

Appendix 6. Location, date, water temperature, and depth of burbot 255 as determined by sonic telemetry and depth sounder.

Date	Location (rkm)	Depth (m)	Water Temperature (°C)
10/26/01	150.8	22.6	9.0
10/29/01	150.8		8.5
11/7/01	151.4	13.1	
11/19/01	167.2	11.6	8.0
11/28/01	169.5	13.4	6.0
12/4/01	167.0		
12/11/01	150.5		
12/20/01	153.2	11.6	4.5
12/28/01	152.9		4.0
1/2/02	153.0		
1/8/02	153.2		
1/25/02	157.0		
2/5/02	157.2	16.8	4.0
2/22/02	152.6	8.2	4.0
3/8/02	152.7	11.6	1.5
9/18/02	154.0	15.9	16.0

Appendix 7. Location, date, water temperature, and depth of burbot 258 as determined by sonic telemetry and depth sounder.

Date	Location (rkm)	Depth (m)	Water Temperature (°C)
11/13/01	150.8		
11/14/01	150.8		
11/16/01	150.7	11.6	8.0
11/19/01	151.0	8.5	8.0
11/21/01	151.0	8.8	7.5
11/26/01	152.0	9.4	6.5
11/28/01	152.0	9.8	6.0
12/4/01	152.1		
12/11/01	152.1		
12/18/01	152.2		
12/20/01	152.1	9.8	4.5
12/28/01	152.0		4.0
1/2/02	152.0		
1/4/02	152.0		
1/8/02	151.7		
1/17/02	152.3		
1/25/02	152.1		
2/22/02	152.7	1.8	4.0

Appendix 8. Steroid levels of nine burbot sampled from the Kootenai River from November 26, 2001 through February 19, 2002. In general, values below 0.60 ng/ml were below the lower limit of detection and are estimates based on control regressions.

Fish #	Date	TL (mm)	WT (g)	Sex	Testosterone (ng/ml)	11-Keto-testosterone (ng/ml)	Estradiol (ng/ml)
1	11/26/01	509	600	Unk	4.72	2.93	0.64
2	12/28/01	682	2,250	Unk	11.71	2.10	2.34
3	2/4/02	762	3,250	M	11.58	13.50	0.50
4	2/19/02	581	925	Unk	12.36	14.10	0.45
5	2/19/02	624	950	Unk	2.66	2.54	0.29
6	2/19/02	627	1,510	M	0	0.35	0.21
7	2/19/02	588	1,450	M	3.09	5.62	0.61
8	2/19/02	770	3,100	M	0.26	0.46	0.16
9	2/19/02	841	4,700	Unk	11.62	13.05	0.49

Appendix 9. Steroid levels of 15 burbot sampled from the Kootenai Tribe of Idaho Hatchery; these fish originated from Duncan Lake, BC. In general, values below 0.60 ng/ml were below the lower limit of detection and are estimates based on control regressions.

FISH #	Date	TL (mm)	WT (g)	Sex	Testosterone (ng/ml)	11-Keto-testosterone (ng/ml)	Estradiol (ng/ml)	Notes
1	04/18/02	615	1,400	M	0.77	1.2	0.15	No spawn
2	04/18/02	758	2,750	F	0	2.55	1.35	No spawn
3	04/18/02	583	1,175	M	3.44	2.45	0.23	Spawned
4	04/18/02	784	2,700	F	0.05	0.78	0.47	No spawn
5	04/18/02	661	2,000	M	0.83	1.30	0.45	No spawn
6	04/18/02	858	3,400	F	0.15	1.90	0.21	No spawn
7	04/18/02	624	1,300	M	0	2.05	0.35	Spawned
8	04/18/02	748	2,460	F	0	0.41	0.35	No spawn
9	04/18/02	635	1,700	M	17.45	2.20	2.68	No spawn
10	04/18/02	581	1,100	F[a]	0	0.54	0.10	No spawn
11	04/18/02	675	1,600	F	0	0.59	0.58	No spawn
12	04/18/02	630	1,000	F[a]	1.93	1.37	0.35	Spawned
13	04/18/02	592	1,200	M	0.15	0.19	0.33	Spawned
14	04/18/02	615	1,200	F	0.10	0.25	0.39	No spawn
15	04/18/02	675	1,700	M	0	1.95	0.12	Spawned

[a] Mortality

Appendix 10. Steroid levels of 11 burbot sampled from a tributary to Columbia Lake, BC. In general, values below 0.60 ng/ml were below the lower limit of detection and are estimates based on control regressions.

FISH #	Date	TL (mm)	WT (g)	Sex	Testosterone (ng/ml)	11-Keto-testosterone (ng/ml)	Estradiol (ng/ml)	Notes
1	02/13/02	452		F	.0.76	1.23	0.29	
2	02/13/02	389		F	0	1.11	0.27	
3	02/13/02	582		M	0.05	1.06	0.28	
4	02/13/02	430		M	0	1.38	0.14	
5	02/13/02	435		Unk	0	0.62	0.09	
6	02/13/02	407		M	0.53	1.75	0.24	
7	02/13/02	638		M	0	1.31	0.36	
8	02/13/02	525		Unk	0	0.62	0	
9	02/13/02	620		M	3.24	3.65	0.13	
10	02/13/02	565		Unk	0.11	0.91	0.08	
11	02/13/02	412		Unk	15.08	2.68	0.23	

Appendix 11. Stepwise movements (≥5 km upstream in ≤10 days) of burbot in the Kootenai River from 1994-2000 as determined by sonic and radio telemetry.

TL (mm)	Weight (g)	Fish iden. PIT tag #	Sex	Mean discharge (m^3/s)	Distance moved (km)	# of days	Rate (km/d)	Movement date	Date Tagged
527	1078	7F7D9D7C76	U	163	8	9	0.9	7/8/94	6/29/94
380	530	none	M	113	5.6	7	0.8	12/22/94	12/14/94
765	2611	34353713629	M	457	5.2	3	1.7	1/24/95	12/13/94
881	3944	34353642952	M	114	7.1	3	2.4	2/24/95	2/17/95
560	1135	7FD0B684C	M	112	6.9	7	1.0	3/16/95	6/29/94
714	2043	34353623996	M	112	5.1	6	0.9	3/17/95	2/1/95
560	1135	7FD0B684C	M	158	57.8	9	6.4	9/11/95	6/29/94
396	400	7FD0D6C6C	M	194	5.7	3	1.9	3/15/96	2/13/96
396	400	7FD0D6C6C	M	169	16.4	4	4.1	4/1/96	2/13/96
703	3100	7F7D0A3031	M	658	6.1	8	0.8	4/18/96	2/20/96
545	1300	7F7D0D7D10	F	297	13.5	8	1.7	5/7/96	2/20/96
648	2100	7F7D0D7748	F	367	7.9	7	1.1	11/19/96	2/20/96
626	1450	7F7D430070	M	471	7	9	0.8	11/27/96	11/22/96
618	1800	7F7D374E69	F	405	8	3	2.7	12/28/96	12/11/96
648	2100	7F7D0D7748	F	561	7.4	7	1.1	1/15/97	2/20/96
595	1356	7F7D401C23	M	511	8	4	2.0	2/10/97	1/19/97
678	1925	7F7D29757B	F	505	8.2	9	0.9	2/11/97	12/4/96
648	2100	7F7D0D7748	F	288	14.4	5	2.9	4/25/97	2/20/96
648	2100	7F7D0D7748	F	310	10.7	9	1.2	9/17/97	2/20/96
648	2100	7F7D0D7748	F	450	6.7	1	6.7	11/19/97	2/20/96
637	1710	7F7D365561	M	415	7.3	4	1.8	11/24/97	10/27/97
688	1850	7F7D403703	M	233	14.8	6	2.5	11/24/97	10/27/97
688	1850	7F7D403703	M	300	5.3	9	0.6	12/15/97	10/27/97
631	1510	7F7D39523A	U	113	7	4	1.8	12/29/97	10/27/97
631	1510	7F7D39523A	U	353	6.3	7	0.9	1/16/98	10/27/97
637	1710	7F7D365561	M	193	17.8	7	2.5	1/21/98	10/27/97
729	2150	7F7D0C124D	U	220	5.4	10	0.5	1/24/98	1/13/98
648	2100	7F7D0D7748	F	113	7.1	1	7.1	1/26/98	2/20/96
747	2750	7F7D321B4E	F	227	8.9	10	0.9	1/27/98	1/13/98
688	1850	7F7D403703	M	282	12.4	6	2.1	1/30/98	10/27/97
648	2100	7F7D0D7748	F	245	8.2	1	8.2	2/2/98	2/20/96
637	1710	7F7D365561	M	245	11.1	1	11.1	2/3/98	10/27/97
650	1900	7F7D431B3C	F	245	5.5	2	2.8	2/4/98	11/18/97
648	2100	7F7D0D7748	F	179	8.6	4	2.2	2/6/98	2/20/96
729	2150	7F7D0C124D	U	112	40.6	7	5.8	4/22/98	1/13/98
729	2150	7F7D0C124D	U	114	65.9	9	7.3	4/29/98	1/13/98
729	2150	7F7D0C124D	U	548	6.5	7	0.9	5/19/98	1/13/98
590	1075	7F7D290934	U	510	3.2	6.1	0.5	1/11/99	12/11/98
590	1075	7F7D290934	U	170	13.2	3	4.4	1/22/99	12/11/98
558	1645	7F7D0E4C2D	U	108	5	6	0.8	5/13/99	12/31/98
605	1500	7F7F3F6161	F	114	7.7	7	1.1	5/17/01	2/5/01
662	1700	7F7D434A22	M	114	14.7	2	7.4	5/23/01	3/10/00
662	1700	7F7D434A22	M	113	6.4	1	6.4	5/29/01	3/10/00
662	1700	7F7D434A22	M	114	14.1	6	2.4	6/18/01	3/10/00
552	1100	7F7D041608	F	378	14.5	5	2.9	1/10/02	11/1/00

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